Chapter 1

Introduction

Bones have been entombed for millions of years in sediments left by ancient lakes, swamps, and rivers that once dotted Ethiopia's Afar Depression. Today, as erosion cuts into these ancient layers, the fossils reach the barren Afar surface, often shattering into small, glistening, multicolored fragments of bone and teeth. Thinly scattered among the osseous and dental remains of thousands of crocodiles, turtles, hippopotami, giraffes, carnivores, baboons, pigs, horses, antelopes, and other animals found in the surface fossil assemblages are the remains of primitive human ancestors. While paleontologists search Afar outcrops for osteological clues about prehistoric human form, archaeologists uncover the osteological remains of the inhabitants of Herculaneum who perished as Mount Vesuvius erupted, burying them with their possessions. On the other side of the globe, anthropologists probe into a recent grave containing skeletal parts that may be those of a Nazi war criminal. And around the world, forensic anthropologists assess the sex and age of recovered remains to help law enforcement officials.

1.1 Human Osteology

A thread that binds these and thousands of other investigations is **human osteology**, the study of human bones. The scientists performing the investigations employ their knowledge of the human skeleton in recovering and interpreting the bones. Outside of anatomical and medical science, there are three main areas in which knowledge of human osteology is often applied. First, osteological work is often aimed at identification of the relatively recently deceased and is usually done in a legal context. This work, which pertains to the public forum, most often a court of law, is called **forensic osteology**, a division of forensic anthropology. The other two contexts in which human osteological knowledge is commonly applied are historical. The context can be ancient and purely **paleontological**, as with the Pliocene pre-cultural hominids of Africa. Alternatively, the context can be relatively recent, part of an **archaeological** record. For example, human bones in the Aztec centers of Mexico were chronicled just a few hundred years ago by the Spanish during the "conquest" of Mexico. Osteological analysis of materials from such cultural contexts is routinely undertaken as part of archaeological research. Archaeologists concentrate on cultural residues of former human occupations, but they stand to gain a great deal of valuable information from the skeletal remains of the ancient inhabitants. It has recently become fashionable to refer to the study of human remains from archaeological contexts as "**bioarchaeology**." However, human skeletal parts are only a small part of the biological remains characterizing most archaeological sites — indeed, most archaeological sites lack human remains altogether!

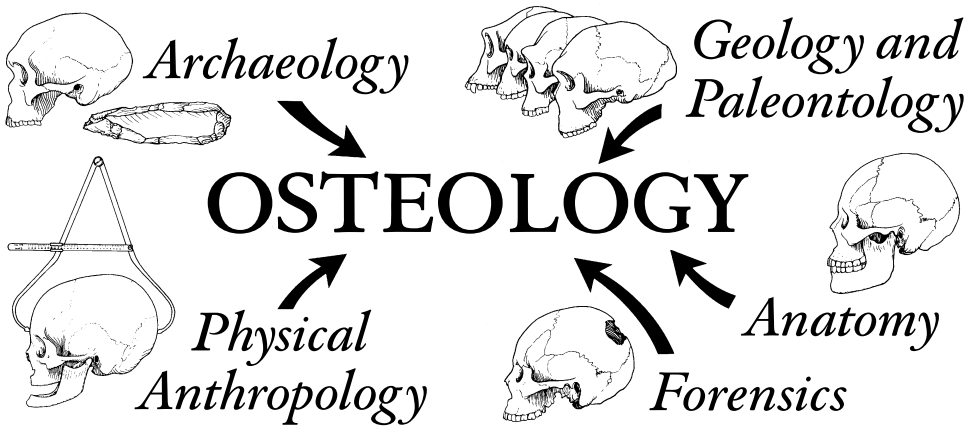

Figure 1.1 **Osteology and associated scientific disciplines.**

The information that human or protohuman remains can provide makes the recovery of bones a critically important activity. Skeletal anatomy (including teeth) reflects the combined action of genes and environment. The skeleton forms the framework for the body, whereas the teeth form a direct interface between the organism and its environment. Bones can carry in their shape, or **morphology**, the signature of soft tissues with which they were associated during life — tissues including muscles, ligaments, tendons, arteries, nerves, veins, and organs. These soft tissues usually disappear soon after death. The skeleton, however, often preserves evidence of the former existence and nature of many of these other body parts.

Because the bones and teeth of the skeleton are resistant to many kinds of decay, they often form the most lasting record of an individual's existence. It is possible to estimate an individual's age, sex, and stature from the bones and teeth. Study of the skeleton often makes it possible to discern a variety of pathologies from which the individual may have suffered. Analysis of groups of individuals may offer insights into prehistoric population structure, biological affinities, cultural behaviors, and patterns of disease. The evolutionary history of humanity itself is being read from the fossil record — a record comprising mostly teeth and bones. Figure 1.1 illustrates the place of osteology in relation to other scientific disciplines.

1.2 A Guide to the Text

The goal of **forensic** osteology often involves identification of an unknown individual. The process of personally identifying the remains of the recently dead individual is called **individuation**. To narrow the possibilities, the forensic osteologist first ascertains whether the remains are human and then begins to explore the individual characteristics, such as age, sex, and stature, comparing these variables in the hope of obtaining an exclusive match with what is known about the missing individual. Human osteologists working in **archaeological** contexts usually cannot perform such personal identification. Rather, their concerns lie with characteristics of the individual and with the insights that skeletal remains of many individuals, representing biological populations, might provide on diet, health, biological affinity, and population history. Osteologists working in a **paleontological** context (and note that many fossils of Pliocene and Pleistocene

age are found in archaeological contexts) are interested in using the normally rare fossil remains of human ancestors and other relatives to learn all these things and also to discern evolutionary relationships.

Skeletal remains can provide meaningful clues about the recent and the ancient past to all these investigators. To use these clues, one must master some fundamentals. This book is about those fundamentals.

The most difficult part of writing and revising this book has been choosing among the many things that could have been included in a single volume. The "perfect" osteology book would be a gigantic volume illustrating all stages of skeletal growth, all variations in the adult skeleton, and all skeletal elements of all mammals that might be confused with a human. It would cover bone histology, skeletal embryology and morphogenesis, and biomechanics. The volume would contain bibliographic references to all papers published in osteology and would include full accounts of every skeletal measurement and identification technique published and all applicable tables. But given the constraints of format, production, and cost, our goal was to produce a single text that is simultaneously accessible to the college student and useful to the practicing professional osteologist. Scheuer and Black's 2000 and 2004 volumes are excellent companions to this book. They present extensive illustrations of immature human skeletal remains.

A book such as this cannot possibly do justice to the large body of professional literature on human osteology available in other books and in journals such as the *American Journal of Physical Anthropology, Journal of Human Evolution, Journal of Dental Research, Human Biology, Paleopathology Newsletter,* and the *International Journal of Osteoarchaeology.* Rather than reprint the data found in these primary sources, and in secondary compilations such as Krogman and İşcan (1986) and Bennett (1993), we have built pathways to them. Our "**Suggested Further Readings**" sections briefly introduce samples of books and professional papers that the reader seeking further details on each chapter topic might consult. All of these references, as well as those cited in the chapter texts, are included in the bibliography at the end of the book. Neither the suggested further readings nor the bibliography attempts to be comprehensive. Instead, these sources were compiled to provide the professional with an orientation to the primary literature and to give the student a set of sound departure points for further study in human osteology and related topics. This approach is intended to encourage all users of the book to directly consult the original literature in the acquisition and application of osteological knowledge. Through this direct approach, advanced students will achieve a better understanding of the nature of original research in human osteology and a firsthand familiarity with the results of this research.

In this book we focus on the first two basic questions that any human osteologist must answer about a bone or collection of bones whether in a forensic, archaeological, or paleontological context:

- **Are the bones human?**
- **How many individuals are present?**

Whether the context is forensic, archaeological, or paleontological, these questions usually must be answered before further analysis is possible. This manual, a guide to human osteology, emphasizes the anatomy of the human skeleton. The skeletal remains of some other animals, particularly when fragmentary, are often difficult to distinguish from human bones and teeth. Although there are no general differences that ensure effective sorting between human and nonhuman bones, the first step in answering the question of whether the bones are human is to become familiar with the human skeleton in all of its many variations in shape and size. France (2009) illustrates whole bones of mammals most often confused with humans, but this confusion rarely involves whole bones. Fragmentary nonhuman remains are more problematic and are encountered more frequently. Once a familiarity with the range, or envelope, of variation characterizing the modern human species is achieved, further work in comparative osteology of both extinct and extant mammals becomes a much easier task. With further comparative work comes more experience, and with that experience the osteologist is better able to make the basic identifications required.

Information on determining the age, sex, stature, and identity of skeletonized individuals is provided in later chapters of the book. These second-level questions and many others, including those about biomechanical capability, phylogenetic relationships, and geographic affinities, however, can be answered accurately only after the elements and individuals have been identified correctly. Too often the first, basic identifications are overlooked or hastily performed, and thus any succeeding analyses are built on weak foundations.

We conclude this introductory chapter by considering some advice on methods and techniques for studying, learning, and teaching human osteology. In Chapter 2 we introduce anatomical terminology — the vocabulary of osteology that is essential in the scientific study of bony and dental tissues. Chapter 3 is an introduction to bone as a tissue. Skeletal growth is introduced here, along with a presentation of the major internal structure and functions of bones, teeth, and joints. The critical topic of intraspecific variation (variation within a species) is discussed and its various sources are identified and illustrated.

Chapters 4–13 form the core of the book. In these chapters we consider one anatomical region at a time, beginning with the bones of the skull. A separate chapter and format are employed for the dentition. We introduce Chapters 4–13 with brief accounts of the phylogenetic history of the body segment(s) and osteological elements described in the chapter. This approach sets the osteological elements in a broad evolutionary framework. These introductory statements are mostly drawn from the excellent functional human anatomy text by Cartmill, Hylander, and Shafland (1987), and the interested reader may pursue further details there and in other comparative texts such as Jarvik (1980) and Shubin (2009).

In the descriptive chapters (4–13), each bone is shown individually, in various views, by means of photographs and, when possible, CT (computerized tomographic) sections. For ease of comparison, the scale for all individual bones is natural size, whereas teeth are shown twice natural size. For paired bones, only the right side is shown unless otherwise indicated. Orientations for the articulated crania are standard, and other bones are illustrated in orientations showing the most anatomy. For example, the "anterior view" of the frontal bone is a photograph of the anterior surface of that bone. Because our focus is on external morphology, and because the dimension of depth is sacrificed when depicting bones and teeth on the printed page, we developed new methods to illustrate osteological form. Our goal was to accurately portray external morphology while minimizing the confusing stains, translucency, and shine found in natural bones and teeth. Details of the preparation and photography of these specimens are given in Appendix 1.

Human osteology texts often depict human skeletons and their elements as if they were interchangeable. Sets of illustrations often provide little or no visual information on the relative sizes of different parts of the skeleton. Furthermore, bones are often unscaled and/or derived from several individuals in such illustrations. This sacrifices additional information on proportionality and fosters misguided typological thinking. To remedy this situation, we chose the skeleton of a single individual to illustrate all the elements of the postcranial skeleton. All postcranial elements shown in the descriptive chapters of this book are from a single modern human individual, Hamann-Todd specimen number 857, a 24-year-old black male who stood 5′7″ tall (170 cm) and weighed 138 lb (62.6 kg). This skeleton was chosen for its relatively few unusual features (noted in the captions for each element), completeness, and excellent preservation. Articulated cranial and all dental specimens illustrated in Chapters 4 and 5 are of recent Mesoamerican origin, and the disarticulated bones of the cranium are all from a single modern individual from Southern Asia. Note that these cranial bones are from a 16-year-old individual whose age allowed the bony elements to be disarticulated and shown intact. This young individual had not fully developed all the markers of cranial robusticity illustrated by the articulated skull.

Each descriptive chapter is organized systematically. The element is first named and its articulations identified. Under the "**Anatomy**" section for each element, the major parts and osteologically significant features of each element are identified in **bold** typeface and described.

The function and soft tissue relations for most structures are identified in *italic* typeface. It is not our intention to give a complete listing of muscle origins and insertions. Instead, we provide

data on soft tissue to make functional sense of bony features while reinforcing the reality of bone as an integral part of the musculoskeletal system. Readings cited at the end of Chapter 3 include human anatomy texts that the student may wish to obtain as companions to this one. Students interested in pursuing soft tissue anatomy are urged to consult these books.

Ossification of each element is briefly considered in the descriptive chapters under a section called "**Growth**." Further details on development of various elements are presented in Chapter 18. The "**Possible Confusion**" and "**Siding**" sections provide information to complement the illustrations and allow effective identification of isolated and fragmentary skeletal elements. The "**Nonmetric Traits**" sections identify and describe the characters most widely used in human osteology, traits largely drawn from Buikstra and Ubelaker (1994), Finnegan (1978), and Pietrusewsky (2002), and present some additional variants not traditionally considered as nonmetric traits. The "**Measurements**" sections provide definitions and techniques employed in gathering metric data from human skeletal remains (largely following Martin, 1928, and Buikstra and Ubelaker, 1994, but also incorporating Arensburg, 1991; Bass, 1995; Bush et al., 1983; Dauber and Feneis, 2007; Flander, 1978; Gómez-Olivencia, et al., 2009; Howells, 1973; Latimer and Ward, 1993; McCown and Keith, 1939; Moore-Jansen and Jantz, 1994; O'Higgins, et al., 1997; Schwartz, 1995; Steele, 1976; Trinkaus, 2003; Trinkaus and Svoboda, 2006; and Trinkaus et al., 1999).

A color atlas of muscle origins and insertions, ligamentous attachments, and articular surfaces for a selection of major bones is presented in Chapter 14. The attachment sites are shown overlain on the bones of the same individual used to illustrate Chapters 4–13, along with CT scans taken of the major long bones.

In Chapter 15 we consider the discovery and recovery of osteological material. This chapter also covers transport of the remains to the laboratory, primary cleaning of the material, and restoration. In Chapter 16 we trace skeletal material through a variety of analytical techniques, including measurement and photography, and we conclude with a section on the reporting of human osteological remains.

In Chapter 17 we consider ethics in osteology. Chapter 18 is a guide to the assessment of an individual's age, sex, race, and stature from skeletal remains. In Chapter 19 we consider some of the most common pathologies encountered in human skeletal remains. Chapter 20 is a discussion of **taphonomy**, the study of processes that affect skeletal remains as they move along the often tortuous path between death and curation. In Chapter 21 we address the subject of how the biology of now-dead human populations, particularly the diet, demography, and affinities, might be studied. Chapter 22 covers the rapidly growing field of molecular osteology.

The text then considers six case studies to show how the fundamentals outlined in the first 22 chapters have been applied in very different investigations involving hominid skeletal material. There are two studies each from forensic, archaeological, and paleontological contexts.

Measurements in this book are expressed in the metric system, as is standard in osteology and most modern sciences. Carter (1980) provides a good history of the English and metric systems for students unfamiliar with metric terms or for those who remain unconvinced of the metric system's utility in modern scientific investigation.

1.3 Teaching Osteology

Instruction in human osteology should begin at the undergraduate level, whether in biology or anthropology. Two of us (TDW and MTB) have found that an intensive, one-semester, upper division course in osteology provides a good foundation for undergraduate and graduate students interested in forensic anthropology, bones in archaeological context, and hominid paleontology. Indeed, courses in these specialty fields prove far more meaningful to students with such a foundation. We have found that students learn best when challenged by frequent examination, when able to access a wide series of original comparative specimens during their studies, and when kept to a rigorous schedule of weekly quizzes and frequent comprehensive exams (with timed identification stations).

This book is topically organized for ease of access by users at all levels. Instructors will have their own preferences for the order of presentation, and the book is organized to allow this. Our personal preference for teaching an introductory human osteology course is to begin with Chapters 1 (introduction) and 2 (terminology), and then proceed directly to Chapters 4 (skull) and 5 (teeth). By covering the skull and dentition chapters early in the semester, the students are continually challenged with the most difficult parts of the skeleton. They work on this for the remainder of the course, thereby maximizing their learning and retention of this information. During the students' laboratory work on the skull and teeth, we cover Chapters 3 (bone biology) and 17 (ethics) and proceed to lecture on recovery and analysis (Chapters 15 and 16), covering the cranial half of Chapter 18 (age, sex, etc.). Case studies are introduced throughout the course. At the midsemester mark we turn to the postcranial skeleton, studying Chapters 6–13 and exploring case studies, population biology (Chapter 21), and molecular osteology (Chapter 22). After the students have mastered basic identification of all elements in the skeleton, the semester finishes up with a look at how paleopathology (Chapter 19) and taphonomy (Chapter 20) extend the morphological envelopes of human skeletal remains. The book and the lectures provide the vocabulary (see the glossary), basic concepts, and references necessary for the student to approach, use, learn, and eventually master the primary professional research literature on human osteology.

1.4 Resources for the Osteologist

The most important single resource for the osteologist is a collection of skeletal remains. Ideally, the laboratory should have a growth series of skeletons of individuals of known age to accompany mounted skeletons of several individuals, as well as element collections in which many individuals of known sex, age, occupation, and pathology are represented. A collection of skeletal remains from a variety of modern nonhuman animals is also very important, as is a cast collection of fossil hominoids. The laboratory should also have a full set of casts of standard comparative sets, such as the ASU dental trait plaques and the Suchey-Brooks pubic symphyseal aging casts. A full set of osteometric instruments is invaluable, as is having access to a radiographic facility for radiographs and CT scans. Access to cadavers for dissection in a human anatomy laboratory is also desirable. Of course, like the ideal textbook, the ideal laboratory can only be approached, never realized.

Beyond the physical plant, proper equipment, and a collection of specimens for analysis and comparison in the laboratory, a key resource for the human osteologist is a comprehensive corpus of publications. A library with comprehensive published resources on forensics, human osteology and anatomy, zooarchaeology, and human paleontology is essential (even smaller libraries can meet this requirement, if they have an active interlibrary loan program). A collaborative community of researchers and students with whom the novice or experienced osteologist can interact completes the ideal setting.

1.5 Studying Osteology

The gulf between knowing the names of elements in an adult skeleton and correctly identifying the taxon, element, and side of an isolated, fragmentary bone or tooth is a wide one. It must often seem to the student that an instructor is performing magic in correctly identifying, for example, a human left upper third premolar. It is, however, far from magic. The ability to identify skeletal material is a skill that can be acquired only through intensive study of actual specimens.

It is not enough to be able to side and identify intact elements, because intact elements are rarely found in field paleontological situations and only sometimes found in archaeological and

forensic contexts. The many hominid specimens "recovered" from faunal collections because they were originally misidentified as nonhominid are ample testimony to many specialists' superficial knowledge of the skeleton. Even the recently published Neanderthal DNA nuclear genome (Green et al., 2010) came from exactly such originally underidentified fragments. Learning to identify bones and teeth can be slow, painful, and frustrating, but the rewards make the effort worthwhile. The loss of scientific data and the professional embarrassment caused by a misidentification make the effort essential.

A great way to reinforce and extend your learning is to partner with another motivated student and challenge each other with numerous mock quizzes. After you've identified a few bones or fragments, using the book and your notes whenever necessary, challenge your partner to identify one of the more difficult pieces in one minute or less, without referring to the book, notes, or other skeletal or comparative material. It's a great way to identify your weaknesses, to improve upon your skills, and to get accustomed to the fast-paced format of osteological quizzes.

Students may find many techniques useful in learning the skeleton. First, remember that the osteologist always has an intact comparative skeleton close at hand, even in remote field situations — the skeleton embedded in his or her own body. It is useful to visualize and even **palpate** (feel your own bones through the skin) the way in which an isolated skeletal element might "plug into" your own body. This is particularly true for identifying and siding teeth, which are conveniently exposed in the osteologist's mouth. Never ridicule an osteologist who holds a radius against the right forearm and then shifts it to the left forearm before identifying it; that osteologist will probably side the bone correctly. When identifying the side of any identified skeletal element, all the osteologist has to do is establish three axes (the plural of axis, pronounced *'ack-sees'*) in space: top to bottom, side to side, and front to back. Anatomical features of the bone will assist in this, thereby providing the clues necessary for correct identification and orientation.

A second tip for identifying skeletal remains involves hierarchies of decisions. Begin identifying a bone by deciding which elements it cannot be. For example, a radius fragment cannot be a cranial bone or tooth (which excludes hundreds of possibilities), a tibia or humerus (too small), a metatarsal (too big), or even a fibula (wrong shape). You will be surprised how soon you can exclude all but the correct choice if you approach identification in this way.

No matter how often you misidentify a bone or tooth, keep trying. Do not constantly use the articulated skeleton or intact skull as a crutch. There is great osteological truth to the idea that "with every mistake we must surely be learning." Try to learn from your mistakes. Try to identify the kinds of mistakes you are making. Are you most often misidentifying immature specimens? If so, set out a growth series for each skeletal element and see how the shape of the bone changes with growth. Are you having trouble with nonhuman skeletal parts? If so, look at a range of human variation to get a good idea of how much variation to expect. Are you simply confusing one part of the skeleton for another? If so, look at all the elements in the skeleton that might mimic each other when fragmentary and check the "**Possible Confusion**" sections in the descriptive chapters of this book. Keep this book nearby. It is much easier to carry than a skeleton, and the life-size photographs in many views should facilitate comparisons and identifications.

1.6 Working with Human Bones

Because the results of human osteology have an impact on so many disciplines, there are a variety of career options that involve human skeletal remains. Most of these choices involve the academic setting. As a result, most professional human osteologists work in colleges, universities, and museums. Even in forensic anthropology, the most "applied" of human osteological endeavors, coroners, medical examiners, and law enforcement agencies most often turn to local or national specialists employed in higher education (Galloway and Simmons, 1997). Most human osteologists and hominid paleontologists are also employed as teachers and researchers in academic settings, often teaching in departments of anthropology or biology or in medical school departments

of anatomy. Some are employed by cultural resource management (CRM) firms, but these positions are often short-term and project-oriented.

Wherever employed, the human osteologist is involved with specimens in collections. As you work with human bones and teeth, always respect them as objects of scientific inquiry. In some ways, skeletal resources are like books in a library. Bones and teeth have the potential, if read correctly, to inform about the living, breathing people to whom they once belonged. Treat these remains with care; some of them are fragile and all of them are irreplaceable.

Respect any system of organization in which you find skeletal material. Never mix bones and teeth of different individuals, even for a short time or with the best of intentions. Remember that mixing of bones results in a loss of contextual information — an action that is potentially even more devastating than physical breakage of an element. In the library, history books shelved incorrectly in the biology section become unavailable to any historian who wishes to consult them. Bones returned to the wrong storage location are almost impossible to retrieve.

Finally, respect the people who came before you by treating their bones with care. Respect the generations of students and professionals who will follow you by keeping the bones and their provenience intact.

Suggested Further Readings

There are several introductory osteology textbooks. These books are highly variable in their content, the quality of their illustrations, and their coverage. In addition to these, the human anatomy books identified at the end of Chapter 4 are useful supplements to the study of human osteology.

Aiello, L., and Dean, C. (1990) *An introduction to human evolutionary anatomy.* San Diego, CA: Elsevier. 608 pp.

A simultaneous introduction to both functional anatomy and paleoanthropology, exploring the types of biobehavioral deductions that can be drawn from human fossils.

Alexander, R. M. (2004) *Human bones: A scientific and pictorial investigation.* New York, NY: Pi Press. 208 pp.

An introduction to human bones and skeletal biomechanics by one of the world's most respected biomechanists.

Baker, B. J., Dupras, T. L., and Tocheri, M. W. (2005) *The osteology of infants and children.* College Station, TX: Texas A&M University Press. 192 pp.

An introductory guide to the identification of immature human skeletal remains.

Bass, W. M. (2005) *Human osteology: A laboratory and field manual* (5th ed.). Columbia, MO: Missouri Archaeological Society. 365 pp.

An introductory manual that emphasizes identification.

Brothwell, D. R. (1981) *Digging up bones* (3rd ed.). Ithaca, NY: Cornell University Press. 208 pp.

A beginner's guide to recovery and analysis of skeletal remains.

Buikstra, J. E., and Ubelaker, D. H. (Eds.) (1994) *Standards for data collection from human skeletal remains.* (Report Number 44). Fayetteville, AR: Arkansas Archaeological Survey. 206 pp.

The essential osteological standards volume in North America.

France, D. (2009) *Human and nonhuman bone identification: A color atlas.* Boca Raton, FL: CRC Press. 584 pp.

Filled with thousands of photographs, this is an excellent guide to nonhuman osteology for forensic anthropologists and others working in North America.

Goldberg, K. E. (1985) *The skeleton: Fantastic framework.* New York, NY: Torstar Books. 165 pp.

An enjoyable, readable guide to the skeleton for the layperson. Excellent color photographs.

Katzenberg, M. A., and Saunders, S. R. (Eds.) (2008) *Biological anthropology of the human skeleton* (2nd ed.). New York, NJ: Wiley-Liss. 680 pp.

An edited volume that brings together 30 specialists to explore recent advances, limitations, and future directions for work in nearly 20 areas of modern osteological research.

Komar, D. A., and Buikstra, J. E. (2007) *Forensic anthropology: Contemporary theory and practice.* New York, NY: Oxford University Press. 362 pp.

A comprehensive overview of the current state of forensic anthropology.

Matshes, E. W., Burbridge, B., Sher, B., Mohamed, A., and Juurlink, B. (2004) *Human osteology & skeletal radiology: An atlas and guide.* Boca Raton, FL: CRC Press. 448 pp.

An introductory text on human osteology that incorporates large numbers of plain film radiographs, CT scans, and MRI images alongside photographs of bones.

Schaefer, M., Black, S., and Scheuer, L. (2009) *Juvenile osteology: A laboratory and field manual.* San Diego, CA: Academic Press. 284 pp.

A concise and easy-to-use quick reference for the identification of immature human skeletal remains.

Schwartz, J. H. (2006) *Skeleton keys: An introduction to human skeletal morphology, development, and analysis* (2nd ed.). New York, NY: Oxford University Press. 416 pp.

An introduction to human osteology.

Shipman, P., Walker, A., and Bichell, D. (1985) *The human skeleton.* Cambridge, MA: Harvard University Press. 343 pp.

A guide that stresses functional aspects of the skeleton at many levels.

Shubin, N. (2009) *Your inner fish: A journey into the 3.5-billion-year history of the human body.* New York, NY: Vintage Books. 256 pp.

An enjoyable introductory book that places the anatomical structures that comprise humans into an evolutionary context.

Steele, D. G., and Bramblett, C. A. (1988) *The anatomy and biology of the human skeleton.* College Station, TX: Texas A&M University Press. 304 pp.

An atlas dedicated to the identification and biology of the human skeleton.

Ubelaker, D. H. (1996) Skeletons testify: Anthropology in forensic science. *Yearbook of Physical Anthropology* 39: 229–244.

An overview of osteology's role in forensic science.

Ubelaker, D. H. (2008) *Human skeletal remains: Excavation, analysis, interpretation* (illust. ed.). New Brunswick, NJ: Aldine Transaction. 146 pp.

A guide to human osteology that emphasizes recovery and interpretation. Excellent photographs of excavations. The text features comparative photographs of skeletal elements of large mammals common in North America.